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(54) Abstract Title
Tape drive cleaning cartridge with data tape leader incorporating memory and communications circuitry

(57) A tape drive system includes a tape drive (12), a cleaning cartridge (20), and circuitry (42, 44). The cleaning cartridge (20) has a tape carrier (22, 28), a data tape segment (38) capable of receiving servo position data, and a cleaning tape segment (40). The circuitry (42, 44) is configured to implement a smart cleaning algorithm (70). The data tape segment is associated with the cleaning tape segment (40) and is capable of receiving servo position data. The tape carrier (22, 28) is configured to carry the data tape segment (38) and the cleaning tape segment (40) for selective positioning along a magnetic transducer head (68) during a head performance verification operation and a head cleaning operation, respectively. A cleaning cartridge (20) and method are also disclosed.

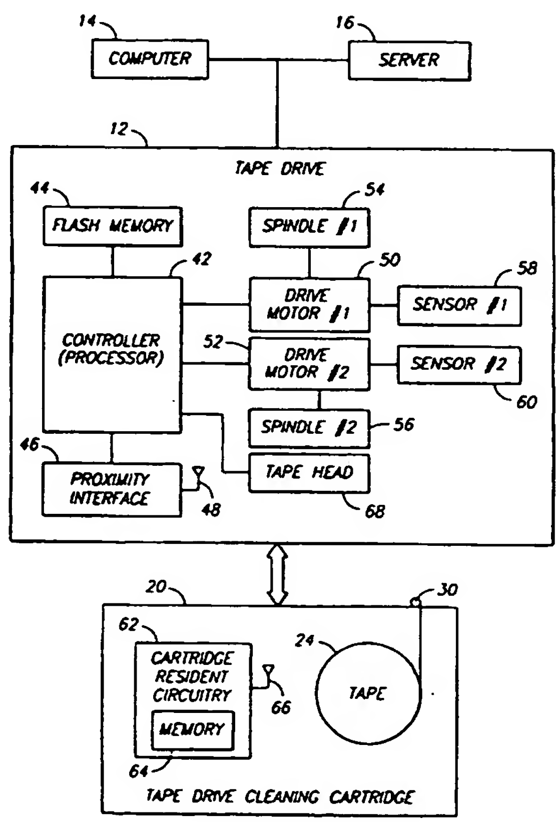

Fig 2

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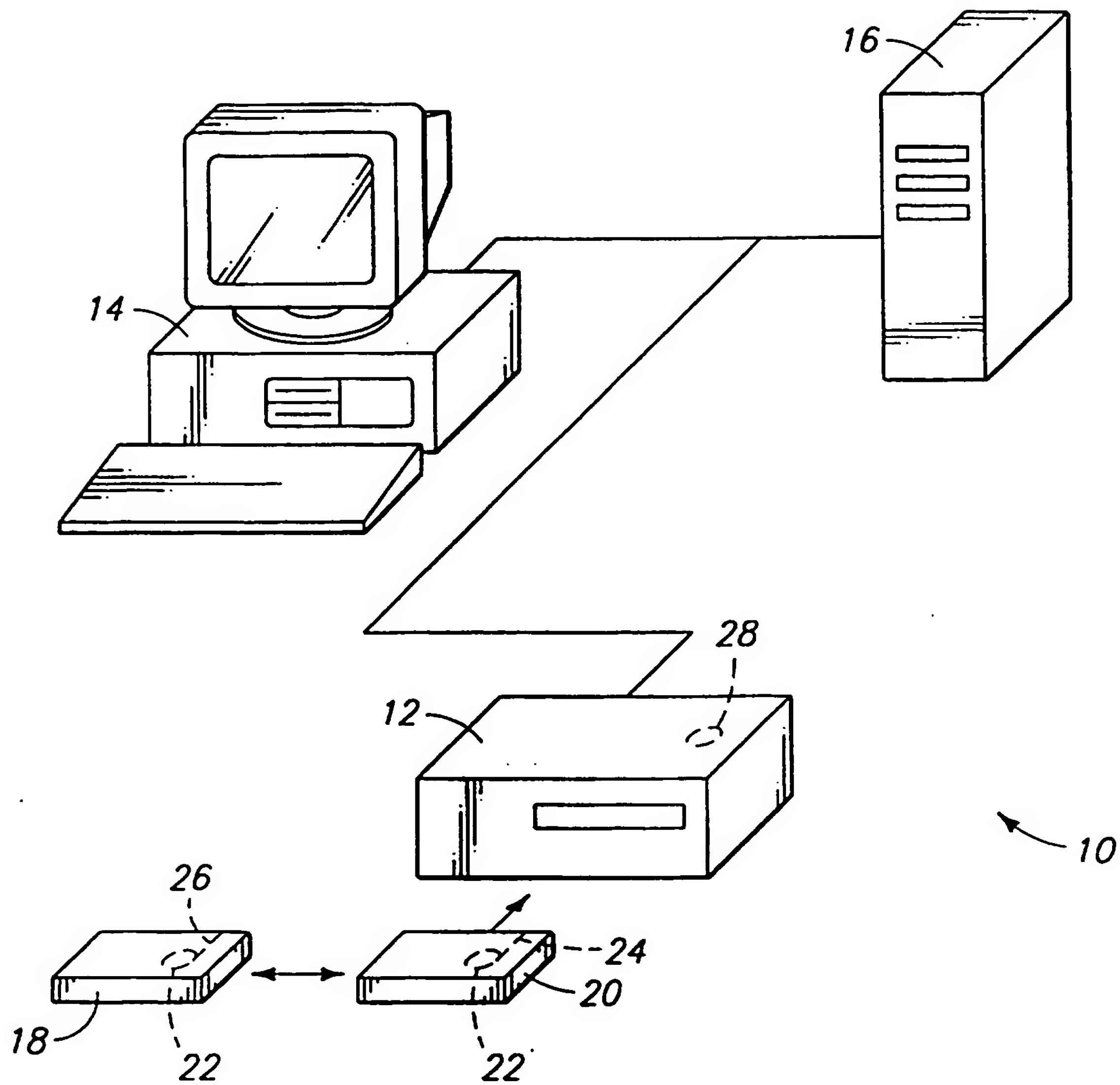

Fig 1

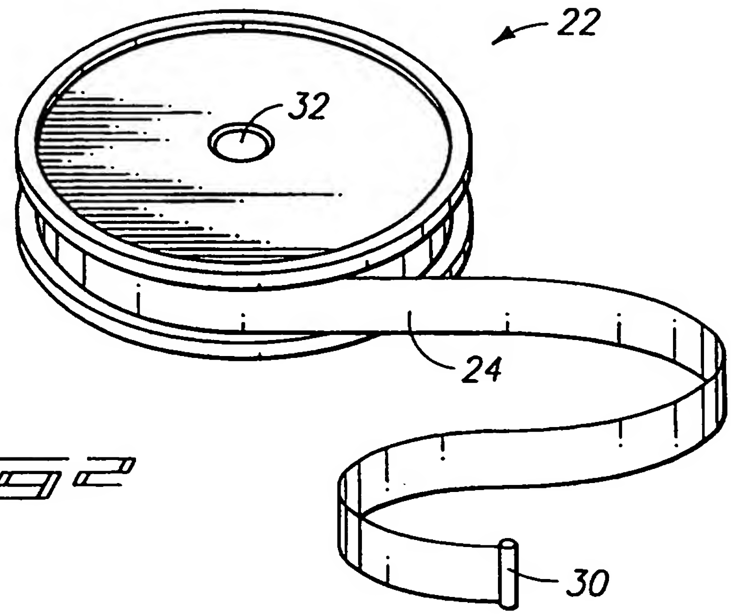

Fig 2

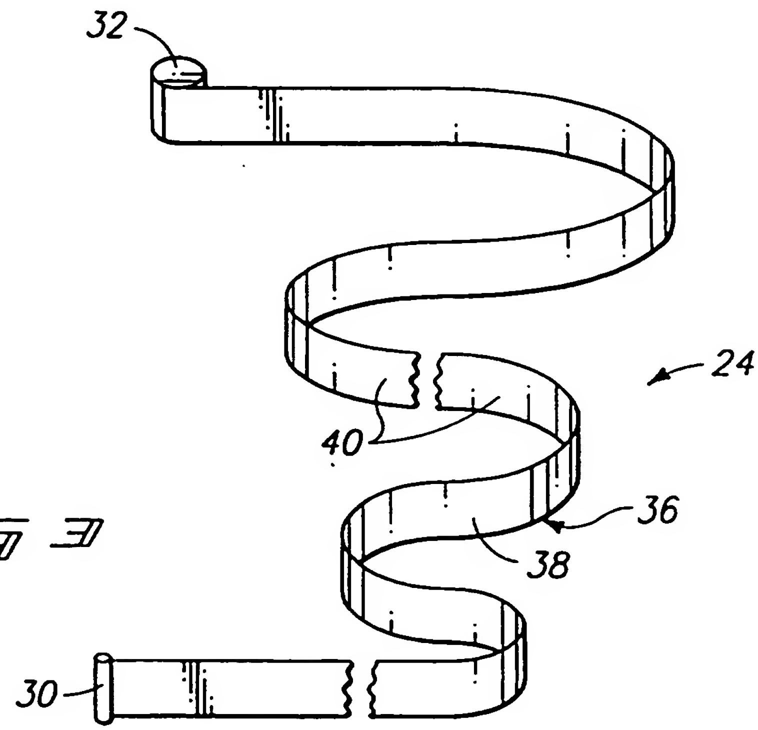

Fig 3

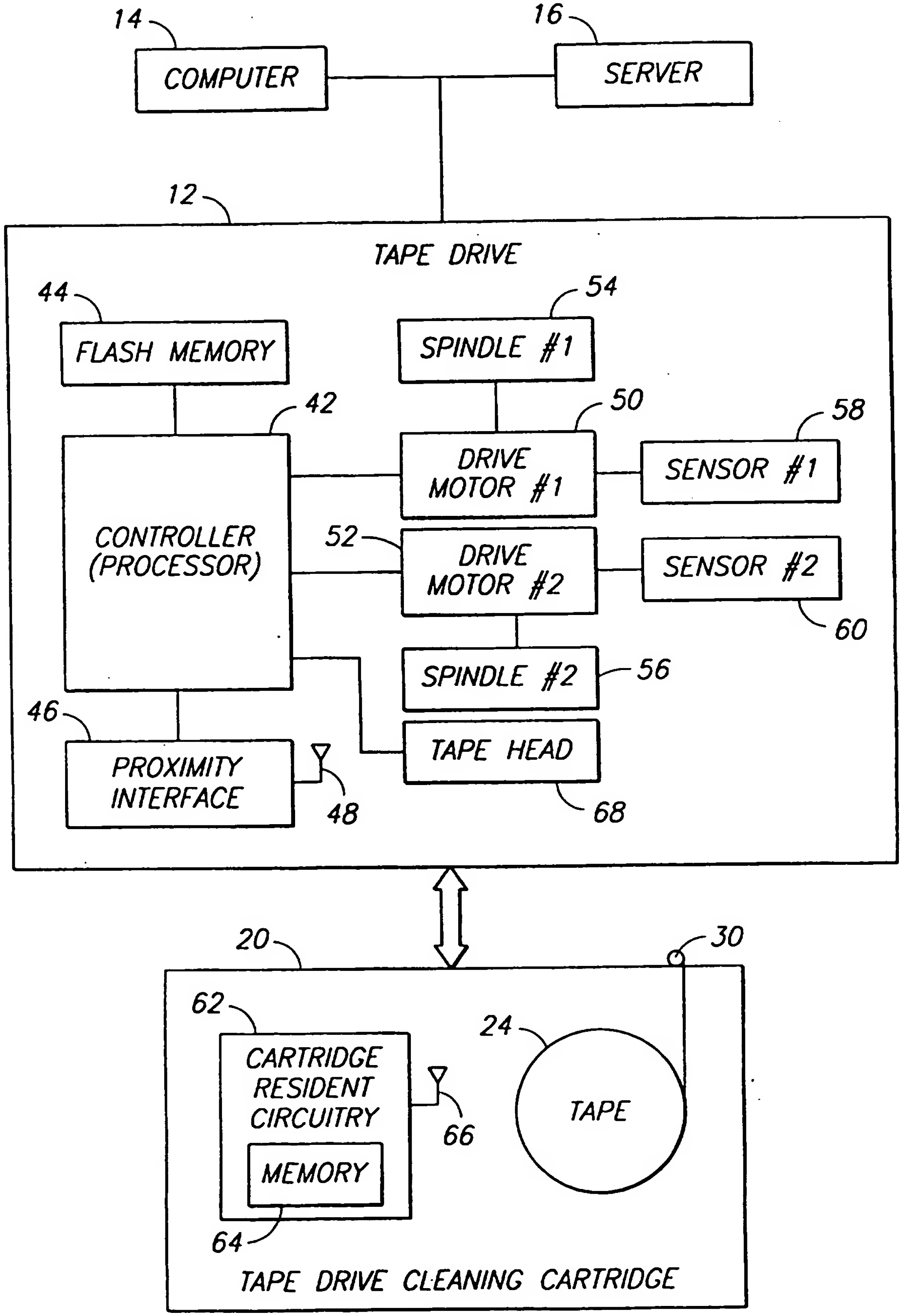
14
COMPUTER
16
SERVER
12
TAPE DRIVE
44
FLASH MEMORY
54
SPINDLE #1
42
50
58
CONTROLLER (PROCESSOR)
DRIVE MOTOR #1
SENSOR #1
52
DRIVE MOTOR #2
SENSOR #2
60
SPINDLE #2
56
46
PROXIMITY INTERFACE
TAPE HEAD
48
68
20
30
62
CARTRIDGE RESIDENT CIRCUITRY
24
TAPE
MEMORY
66
64
TAPE DRIVE CLEANING CARTRIDGE

Fig 4

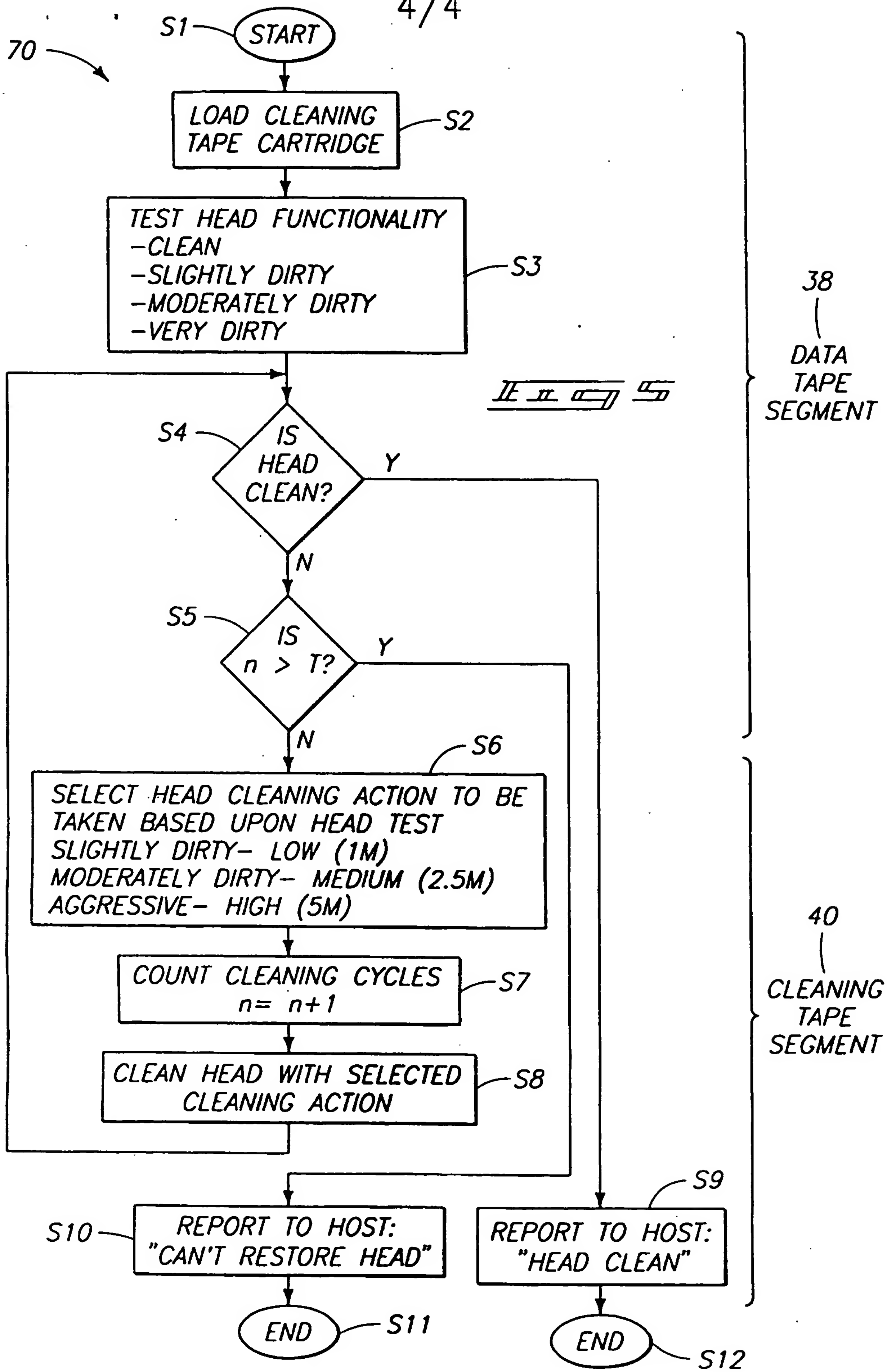
70
S1
START
LOAD CLEANING TAPE CARTRIDGE
S2
TEST HEAD FUNCTIONALITY
-CLEAN
-SLIGHTLY DIRTY
-MODERATELY DIRTY
-VERY DIRTY
S3
S4
IS HEAD CLEAN?
Y
N
S5
IS n > T?
Y
N
S6
SELECT HEAD CLEANING ACTION TO BE TAKEN BASED UPON HEAD TEST
SLIGHTLY DIRTY- LOW (1M)
MODERATELY DIRTY- MEDIUM (2.5M)
AGGRESSIVE- HIGH (5M)
COUNT CLEANING CYCLES
n= n+1
S7
CLEAN HEAD WITH SELECTED CLEANING ACTION
S8
S9
S10
REPORT TO HOST: "CAN'T RESTORE HEAD"
REPORT TO HOST: "HEAD CLEAN"
END
S11
END
S12
38
DATA TAPE SEGMENT
40
CLEANING TAPE SEGMENT

FIG. 5

TAPE DRIVE CLEANING CARTRIDGE WITH DATA TAPE LEADER

FIELD OF THE INVENTION

This invention relates generally to tape recording and playback systems for magnetic storage devices, and more particularly to a system which uses a cleaning cartridge having a data tape segment and a cleaning tape segment configurable to effect improved cleaning of a transducer for a recording and playback mechanism.

BACKGROUND OF THE INVENTION

Recording/playback systems for magnetic medium are subject to degradation during use as a result of the accumulation of debris which occurs on the magnetic transducer head(s) of such systems. Transducer heads include magnetic read/write heads and associated read/write elements. Hence, there is a need to periodically clean the magnetic transducer head(s). Accordingly, there exist several techniques for cleaning a magnetic transducer head.

One prior art technique utilizes a separate, dedicated "cleaning cartridge" to perform periodic cleaning of the recording transducer. A "cleaning cartridge" contains a supply of unrecorded abrasive tape that is used to clean one or more magnetic transducer heads. For example, the recording heads found on a tape drive can be cleaned with a "cleaning cartridge". In order to utilize a "cleaning cartridge", the recording/playback of the medium must be stopped, with the data cartridge being removed, and the cleaning cartridge being inserted. The "cleaning cartridge" is then run within the record/playback system so as to clean the recording transducer. Once cleaning is complete, the "cleaning cartridge" is removed, and a data cartridge is reinserted. However, after the "cleaning cartridge" has been used, a new data cartridge must be loaded into the system in order to evaluate the performance of the magnetic transducer head so as to confirm that cleaning has been successfully completed.

Where the magnetic recording/playback system is a tape recording/playback system, the cleaning cartridge includes an abrasive cleaning tape that can cause excessive tape head wear. The abrasiveness of the cleaning tape can be adjusted in order to tailor its effectiveness. If the cleaning tape is made sufficiently effective to thoroughly remove debris from the read/write heads, then the cleaning tape should only be used when it is necessary; otherwise, excessive head wear will result. Such a problem can occur where a piece of abrasive cleaning tape is provided as a leader on a data tape cartridge such that each time a tape is used the leader is used to clean a read/write head. Furthermore, the provision of an abrasive tape leader within a data tape cartridge eventually results in degradation of the abrasive leader from debris accumulating on the cleaning tape. If the abrasive cleaning tape is made sufficiently effective to thoroughly remove debris from a magnetic head, then a routine must be established to limit use of the cleaning tape only when it is necessary.

Where magnetic tape is used to store computer data, the presence of errors represents a significant problem even if the errors occur infrequently. In certain applications, the loss of data requires that a user be able to perform a cleaning operation in response to recognized drop-out errors, but does not immediately prevent use of the equipment prior to cleaning. In some cases, the loss of a single bit of computer data can be of significant importance, and recovery from such an error must be done in a manner that ensures error-free data storage and retrieval. While error correction is possible via error correction algorithms, data loss can still present problems to a user.

One form of magnetic storage comprises existing linear and helical scan tape drives that are used for storage and retrieval of computer data. Such tape drives use a single reel in the form of a magnetic tape cartridge to house the magnetic tape media. A special leader or leader block is attached to the magnetic tape media at one end which enables the tape drive to extract the magnetic tape from the magnetic tape cartridge.

"Leader tape" is typically constructed of a piece of thicker, stronger tape that is sometimes used between the magnetic storage tape and the hub reel. Leader tape has been used to perform various functions, including identification, timing and an ability to resist wear. Leader tape can be located anywhere along a segment of tape, although it is typically found at the ends of a reel of tape. Accordingly, the leader can form a "leader tape" at the leading end of a tape reel, or a "trailer tape" at a trailing end of a supply reel. For purposes of this disclosure, "leader tape" will be used to refer to placement of such a tape at either end of a magnetic tape media.

"Tape recorder" is intended to refer to one form of magnetic recording/playback system comprising magnetic tape transcription equipment. Such equipment is understood to include standard tape recorders having fixed or movable heads, as well as arcuate scan and helical scan transcription equipment as is typically used in analog and digital tape recorders. According to one implementation, a linear transcription head is employed, although such invention has application in other tape recording environments. As described here, "transcription" is intended to mean read and/or write operations that are performed with a tape recorder, and is not intended to be limited to a particular use or format for data.

Another prior art magnetic tape recording/playback system includes music cassette tapes that are often configured to include special material presented on a leader tape. Such music cassette tapes are configured with leader tapes that are presented over a head at the beginning sequence of operating the tape. Such leader tapes have been provided with a limited amount of abrasive cleaner. However, if the leader tape is provided with an abrasive cleaner having sufficient strength for cleaning a tape head, the leader tape will tend to cause undue wear to the tape head. Such undue wear results because each use of the tape is not selective and will cause abrasive cleaning, whether it is necessary or not. Therefore, end-of-tape abrasive leaders have limited application in that the abrasiveness, or cleaning effectiveness, must be reduced so that excessive wear does not occur to the tape head. Furthermore, there is

no capability for determining whether a head needs to be cleaned, or whether or not a head has been sufficiently cleaned.

It is therefore desirable to employ a tape drive cleaning cartridge with a tape drive system that is capable of sufficiently cleaning a magnetic head of the system without imparting undue wear to such head, and while allowing the tape drive to check head recording performance and verify successful cleaning. It is further desirable to monitor the use of cleaning tape within a cleaning cartridge in order to determine its previous use and to ensure that an effective, and sufficiently abrasive, segment of cleaning tape is presented to a head being cleaned.

It is further desirable to tailor the timing and degree of cleaning imparted to a head of a magnetic transcription device so as to ensure sufficient cleaning while minimizing head wear, all while tailoring the cleaning to a detected need to clean such head. Furthermore, there is a desire to deliver cleaning to a head in proportion to the degree with which the head is contaminated.

SUMMARY OF THE INVENTION

The invention provides a device and method for ensuring cleaning of transducer heads on a magnetic storage system such as magnetic heads on a tape drive system. The device comprises a tape drive cleaning cartridge having a tape carrier, an abrasive tape segment, and a data tape segment capable of receiving servo-track position data. The tape carrier is configured to selectively deliver the abrasive tape segment across a magnetic head to sufficiently and thoroughly clean the magnetic head, and to deliver a data tape segment to initiate successful cleaning of the magnetic head.

One aspect of the invention provides a tape drive cleaning cartridge including a cleaning tape segment, a data tape segment, and a tape carrier. The data tape segment is associated with the cleaning tape segment and capable of receiving servo position data. The tape carrier is configured to carry the cleaning tape segment and the data tape segment for selective

positioning along a magnetic transducer head during a head cleaning operation and a head performance verification operation, respectively.

Another aspect of the invention provides a tape drive system including a tape drive having circuitry and a transducer head. A cleaning cartridge of the system has a tape carrier, a cleaning tape segment configured to clean the transducer head, and a data segment capable of receiving servo position data. The system also includes circuitry configured to implement a smart cleaning algorithm that tests the head with the servo position data, cleans the head with the cleaning tape segment, retests the head with the servo position data and recleans the head with the cleaning tape segment, if necessary.

Yet another aspect of the invention provides a method for cleaning a transducer head on a tape drive. The method includes the steps of: providing a cleaning cartridge having a tape including a data tape segment and a cleaning tape segment; receiving the cleaning cartridge into a tape drive; operating the tape drive and the transducer head in order to transfer data between the data tape segment and the tape transducer head; detecting when the tape transducer head requires cleaning; advancing the tape along the cleaning tape segment in response to the detected need for cleaning, the advancing resulting in the cleaning tape segment effecting a cleaning operation on the tape transducer head; and advancing the tape to the data tape segment to detect whether the transducer head is clean.

DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings depicting examples embodying the best mode for practicing the invention.

Fig. 1 is a perspective view of a computer network environment including a data storage device embodying the invention.

Fig. 2 is a simplified perspective view of a reel of tape according to this invention as implemented within a cleaning cartridge.

Fig. 3 is a simplified partial perspective view of the tape of Fig. 2 illustrating the tape removed and unrolled from the reel.

Fig. 4 is a schematic block diagram illustrating in further detail the tape drive system and tape drive cleaning cartridge of Figs. 1-3, configured for cleaning a magnetic head and verifying successful cleaning of the head.

Fig. 5 is a flow chart illustrating how the tape drive system and tape drive cleaning cartridge effectively clean a magnetic head and verify such cleaning.

DETAILED DESCRIPTION OF THE INVENTION

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts". U.S. Constitution, Article 1, Section 8.

Figure 1 illustrates a computer network environment 10 including a data storage device, or system, 12 embodying this invention, and including a computer 14 and a network server 16. Computer 14 is configured to read data from and write data to data storage device 12. Additionally or optionally, server 16 is configured to read data from and write data to data storage device 12. Computer 14 and network server 16, together or individually, form a host system that is connected with data storage device 12. According to one embodiment, data storage device 12 comprises a data storage/retrieval device configured in the form of a stand-alone computer tape drive. According to another embodiment, data storage device 12 is supported in a bay inside a housing of computer 14 or server 16.

As illustrated in Figure 1, data storage device 12 is a linear recording tape drive. Although the one embodiment illustrated in Figure 1 is employed in a computer data storing tape drive system, the invention is understood to have a wide variety of applications. For example, certain aspects of the invention can be used in connection with other magnetic storage media, for storing either analog or digital information. Some aspects of the invention can be employed, for example, in connection with any of a variety of types of

storage devices having read/write heads, including linear, helical and serpentine tape drives. For purposes of illustration, the invention will be described in connection with a computer tape drive.

As shown in Figure 1, tape drive 12 is configured to be used with tape cartridges such as a data cartridge 18. In the illustrated embodiment, data cartridge 18 is a single-reel type tape cartridge. Such tape data cartridge 18 includes a tape carrier in the form of a reel 22, and tape 24 wound onto reel 22. A second reel 28 is included in tape drive 12, and is configured to engage tape 24. Second reel 28 cooperates with first reel 22 to form a tape carrier. According to an alternative construction, data tape cartridge 18 includes two reels. According to one implementation, tape 24 is configured with a width, W, of one-half inch. Such tape 24 has a length extending in a direction perpendicular to width W, with a plurality of parallel tracks being defined across the width of tape 24. Such tracks extend in the direction of the length of tape 24, and are used for storing data as well as storing servo information.

Also shown in Figure 1 is a tape cleaning cartridge 20 configured for cleaning one or more magnetic tape heads 68 (see Fig. 4) contained within tape drive 12. Cleaning cartridge 20 is configured in the form of a case that is sized substantially identical to the case provided for data cartridge 18. Cleaning cartridge 20 is also shown in a single-reel type cartridge construction and includes a reel 22 and a tape 24 that is wound on reel 22, although a two-reel construction is also envisioned. Cleaning cartridge 20 contains a reel 22 that is substantially identical to reel 22 of data cartridge 18.

As shown in Figure 1, it is understood that computer tape drive 12 includes a magnetic tape head 68 (see Fig. 4) that contains a plurality of read/write elements for reading data from or writing data to tape 26 of cartridge 18. Magnetic tape head 68 comprises and transducer head. Additionally, a plurality of servo elements are configured for reading/writing servo code from tape 26. Additionally, such servo elements on the tape head are configured for reading/writing servo information as well as data from a portion of tape 24. The performance of individual transducer heads can be tested using a segment 38

(see Figs. 2-3) of data tape on tape 24 in order to verify that head cleaning is required.

Figures 2 and 3 illustrate the physical appearance of reel 22 and tape 24, as implemented within cleaning cartridge 20. It is understood that reel 22 and tape 26 of data cartridge 18 are similarly constructed, but wherein tape 26 is configured solely for reading/writing data and servo information. Additionally, Figure 3 illustrates the sequential arrangement of portions of tape 24.

As illustrated in Figures 2 and 3, an inner end of tape 24, along reel 22 and adjacent hub 32, is formed by cleaning tape segment 40 which is physically wrapped around hub 32 several turns to facilitate securement of tape 24 to hub 32. As long as tape 24 is not completely unwound from hub 22, tension on tape 24 provides for securement. Cleaning tape segment 40 connects to a data tape segment 38 with a splice 36. Cleaning tape segment 40 includes abrasive material for cleaning tape heads or transducers (not shown).

Data tape segment 38 of tape 24 is connected to an outer end of cleaning tape segment 40, with an outer end of data tape segment 38 being secured to a leader pin, or leader block, 30. Data tape segment 38 is wrapped around a central pin of leader pin 30, and a polymer spring and a steel spring keeper secure tape segment 38 within the assembly comprising leader pin 30. Leader pin 30 is supported externally of cleaning cartridge 20 (of Fig. 1) such that tape drive 12 can readily engage leader pin 30 where it is received into second reel 28 upon loading of cleaning cartridge 20 into a tape drive. Leader pin 30 enables the tape drive to extract the magnetic tape 24 from a magnetic tape cartridge. Hence, tape 24 is delivered between reel 22 (of Fig. 3) and reel 28 (of Fig. 1).

Optionally, a leader section can be attached to the inner end of cleaning tape segment 40 via a splice, with the leader section being attached to hub 32. Similarly, an optional leader section can be attached to the outer end of data tape segment 38, with the leader section being attached to leader pin 30.

Further optionally, tape 24 can contain data tape segment 38 and cleaning tape segment 40 is reverse positions, or can contain multiple segments of one or more of each segment arranged in any of a number of possible configurations. For these cases, a magnetic head can be retracted when moving the cleaning tape segment to access the data tape segment in order to minimize head wear. As long as the position of each segment of data tape and cleaning tape can be repeatedly and accurately located across a magnetic head, such selective head testing and cleaning can be implemented. One way to accurately located tape segments is to monitor rotation of tape reels as discussed below.

In normal operation, cleaning cassette 20 is loaded into tape drive 12 of Figure 1. Hub 30 (of Fig. 3) is fed into engagement with second reel 28 (of Fig. 1) such that tape 24 is supported between reel 22 (of Fig. 2) and reel 28 (of Fig. 1) where it is stored by wrapping tape 24 about each reel 22 and 28. More particularly, tape 24 is wrapped onto reels 22 and 28 which are rotated so as to move tape 24 between such reels. Cleaning tape segment 40 of tape 24 is positioned to run across one or more tape heads, with such action resulting in the tape heads being cleaned. The mere presence of abrasive material on/within cleaning tape segment 40 results in a tape head being cleaned because the tape head itself is placed into motion during a cleaning operation. Accordingly, cleaning, as well as abrasion, of the tape heads occurs only when cleaning tape segment 40 is present at the tape heads. In contrast, placement of data tape segment 38 being run across the tape heads does not result in cleaning or abrasion. Instead, data tape segment 38 is run across such heads in order to initialize tape placement, determine the need to clean such heads, as well as to determine whether cleaning has been performed sufficiently to justify removal of cleaning cartridge 20 from tape drive 12 (of Fig. 1) or detect a deficient head condition.

As shown in Figures 1 and 2, cleaning cartridge 20 comprises an abrasive cleaning cartridge that contains a supply of unrecorded abrasive cleaning tape in the form of cleaning tape segment 40 and a supply of data tape in the form of data tape segment 38. The provision of data tape segment 38

allows writing of servo information and data onto data tape segment 38 which enables tape cleaning, setup and testing of head performance. Cleaning tape segment 40 is spliced to data tape segment 38 to allow for head cleaning. Cleaning tape segment 40 is configured without any servo pattern, and is solely dedicated for cleaning of tape heads. According to one construction, data tape segment 38 comprises a standard recording tape on which a standard servo pattern has been recorded via a tape head.

In operation, data tape segment 38 is used to support standard data cartridge load and unload operations, and to assess the recording performance of a recording head on the tape head. Provision of data tape segment 38 within a cleaning cartridge allows a tape drive to verify that transducer head performance is restored after cleaning without the need to load a separate data cartridge.

Generally, there exist a number of features known in the art for getting a data tape into a tape drive, and getting it up and running. One such feature is a standard cartridge load algorithm. Such standard algorithms enable functionality within a disk drive and include a loading algorithm configured to enable loading of a data tape. Such a loading algorithm brings a tape up to speed, locks a servo onto the tape and reads servo code from the tape magnetic heads. Accordingly, such loading algorithm monitors specially written tracks that are provided on the data tape. Similarly, a standard unload algorithm can be used that relies on position marks recorded on the data tape.

Another standard algorithm is configured for moving an azimuth tilt head for alignment, and enabling power-on alignments. Accordingly, tape 24 (of Fig. 3) can enable such standard algorithms by way of formatting data tape segment 38 in an identical manner that a standard data tape would be formatted. Hence, the front end of tape 24 can be used as a standard data cartridge tape such that operation of a tape drive can be assessed upon loading of a cleaning cartridge therein. Such data tape provision eliminates the need to try to servowrite the abrasive cleaning tape. Servowriting of abrasive cleaning tape would not be practical because of resulting extreme servowriter head wear.

According to Figure 4, controller 42 can be implemented to sequentially identify each magnetic head, and to assess whether each head is contaminated and is causing troubles by misreading data. For example, the level of magnetic head performance can be determined in order to quantify the level of cleaning needed to restore head functionality. If tape drive performance is not fully restored after a first cleaning operation, the data tape allows the tape drive to assess the condition of the transducer heads and initiate a second more aggressive reclean algorithm if necessary without the need to load a separate data tape. Furthermore, the effectiveness of cleaning can be evaluated individually with each head, by sequentially monitoring and identifying the read/write capabilities of each head before and after cleaning. If the transducer heads cannot be cleaned and the tape drive performance cannot be restored, the tape drive can signal failure to restore performance to a host without the need to load a separate data cartridge.

One example of implementing a performance evaluation for each head involves utilization of an error rate test, wherein one or more magnetic heads has difficulty reading/writing data because it is clogged with debris that has built up on the head. Such head clogging can be originally observed when reading/writing data from a data cartridge. Alternatively, such head problems can be observed by data tape segment 38 on cleaning cartridge 20. By measuring the error rate on each head, the rate at which errors are made on each head can be assessed, followed by cleaning such head, and remeasuring or remonitoring the performance and comparing it with the original performance. When it is determined that the cleaned performance is not good enough, recleaning can be performed until the measured error rate is reduced or eliminated.

Figure 4 illustrates in block diagram form one embodiment of the invention implemented between cleaning cartridge 20 and computer tape drive 12. Tape drive 12 is signal-coupled with a computer 14 and server 16 for transmitting data pertaining to read/write operations. Tape drive 12 contains a

central controller (or processor) 42, a flash memory 44, a proximity interface 46, an interface antenna 48, and a pair of drive motors 50 and 52.

According to one construction, controller 42 comprises a 16-bit microprocessor. Additionally, flash memory 44 comprises 300K bytes of flash memory. Such flash memory receives operating algorithms that run tape drive 12. Additionally, a smart cleaning algorithm described below with reference to Figure 5 is also resident in flash memory 44, along with other standard algorithms that enable functionality of the tape drive, involve the tape in some way, enable reel motor calibration via encoder or sensor calibration, and enable start-up of tape drive 12.

Drive motors 50 and 52 are each coupled for mated rotation with an associated spindle 54 and 56, respectively, to drive each spindle in rotation. Each spindle 54 and 56 engages and moves one of reels 22 and 28, respectively, in rotation. One motor is used to drive tape 24 in one direction, and the other motor is used to drive tape 24 in an opposite direction. Sensors 58 and 60 detect relative movement of drive motors 50 and 52, respectively. According to one construction, sensors 58 and 60 comprise Hall-effect position sensors which monitor rotation of electric drive motors 50 and 52.

Spindles 54 and 56 are configured to drive reels 22 (see Fig. 2) and 28 (see Fig. 1) such that tape 24 is transported therebetween. Sensors 58 and 60 enable the determination of axial movement of tape 24 between such reels by monitoring motion of each reel 22 and 28. By monitoring the motion of each reel 22 and 28 via sensors 58 and 60, respectively, a relatively accurate calibration can be performed which enables determination of the exact placement of tape 24 across a tape head 68 of tape drive 12.

It is understood that spindles 54 and 56 are each provided within tape drive 12 such that a pair of hubs can be driven to move a tape across a tape head 68. For the case where the data storage device comprises a single-reel type tape cartridge, one reel 22 (see Fig. 2) is contained within a cartridge 18/20 (see Fig. 1), and another reel 28 is contained within tape drive 12. For the case where the data storage device is configured for use with a dual-reel

type tape cartridge, both reels are contained within the cartridge. Irrespective, spindles 54 and 56 are configured to engage and drive each reel in rotation such that a tape can be driven between the pair of reels while it is being presented across a tape head 68.

As shown in Figure 4, cleaning tape segment 40 includes tape 24 which is rolled onto reel 22. Accordingly, tape 24 is stored within a housing of cartridge 20 when not in use. As shown, hub 30 enables retraction of tape 24 from hub 22 and into tape drive 12. The design of such a single-reel type tape cartridge is well understood in the art. Tape drive cleaning cartridge 20 also includes cartridge resident circuitry 62 comprising a semiconductor chip having circuitry including a memory 64, transmitting/receiving circuitry (not shown) and a passive antenna 66. According to one construction, cartridge resident circuitry 62 comprises a Memory-In-Cartridge (MIC). Circuitry 62 is configured with transmitting/receiving circuitry in combination with antenna 66 such that proximity interface 46 and antenna 48 on tape drive 12 can communicate with circuitry 62. One reason for communicating between proximity interface 46 and circuitry 62 is to enable determination of when cleaning cartridge 20 is inserted within tape drive 12. Another reason is to transmit information from tape drive 12 onto memory 64, which records usage of cleaning cartridge 20. Such usage information can be utilized in determining when cleaning cartridge 20 needs to be replaced. Alternatively, memory 64 is signal coupled with a processor of controller 42 by a signal connector that couples between the cleaning cassette and the tape drive when the cleaning cassette is loaded.

As shown in Figure 4 and for purposes of this disclosure, controller (processor) 42, flash memory 44, circuitry 62 and memory 64 cooperatively and individually comprise circuitry that enables functionality of this invention, and further enables implementation of standard algorithms and a smart cleaning algorithm pursuant to this invention.

A smart cleaning diagnostic system can be implemented via controller 42 and memory 44 of tape drive 12, as shown in Figure 4. Details of

such a smart cleaning diagnostic system and algorithm are described below with reference to the flow chart depicted in Figure 5.

According to the logic flow diagram of Figure 5, a "smart cleaning algorithm" 70 is disclosed as a first level logic flow diagram for the programming of the processor, or controller, of the tape drive. The "smart cleaning algorithm" 70 is used to implement cleaning of one or more tape heads within the tape drive upon loading of the cleaning cartridge. Furthermore, such smart cleaning algorithm determines when sufficient cleaning has occurred to such tape heads. Even furthermore, such smart cleaning algorithm determines when a head condition is sufficiently degraded such that the head can no longer be restored to a proper clean condition.

The logic flow diagram of Figure 5 is initiated in one of several ways. According to Step "S1", an automated start-up procedure can be used to initialize the start of the smart cleaning algorithm 70 when a cleaning cartridge is inserted within a tape drive such that the proximity interface 46 and antenna 48 detect loading of the cleaning cartridge via circuitry 62 and antenna 64 (see Fig. 4). After initiating the "smart cleaning algorithm" 70 at Step "S1", the process proceeds to Step "S2".

In Step "S2", the logic flow diagram is initiated by the processor when the cleaning tape cartridge is detected as being loaded by the processor. After performing Step "S2", the process proceeds to Step "S3".

In Step "S3", the processor initiates the testing of tape head functionality by implementing standard data cartridge algorithms which initialize a data tape cartridge, but are herein performed on the data tape segment. After performing Step "S3", the process proceeds to Step "S4".

In Step "S4", the processor detects whether the head is clean by reading data and servo information from data tape segment 38. If it is determined that the tape head is clean, the process proceeds to Step "S9". If not, the logic flow diagram implementation proceeds to Step "S5".

In Step "S5", the processor compares the counted number of clean cycles with a threshold number T. If the number of cleaning cycles exceeds the

threshold value, the processor proceeds to Step "S10". If not, the process proceeds to Step "S6".

In Step "S6", a processor compares information that quantifies how clean the tape head actually is and assigns one of a plurality of values that indicates the degree of cleanliness or head contamination that was detected. Based upon the level of head contamination detected, an appropriate action is assigned by the processor to later direct movement of a specified longitudinal distance of cleaning tape segment across the tape head being cleaned, in Step "S8", which matches the detected level of head contamination. Accordingly, the processor initiates placement of tape 24 so that the cleaning tape segment 40 is presented for movement across the tape head. After performing Step "S6", the process proceeds to Step "S7".

In Step "S7", the processor counts the number of cleaning cycles that have been undertaken, each time incrementing by one the number of cleaning cycles which have been undertaken. After performing Step "S7", the process proceeds to Step "S8".

In Step "S8", the processor initiates actual cleaning of the head corresponding to the selected head cleaning action from Step "S6" by enabling associated drive motors to move the tape to a location such that cleaning tape segment 40 is moved across the tape head being cleaned. After performing Step "S8", the process proceeds to Step "S3".

In Step "S9", the processor reports to a host, such as computer 14 or server 16 (of Fig. 4), the condition of the tape head being cleaned as "head clean". After performing Step "S9", the process proceeds to Step "S12".

In Step "S10", the processor reports to the host, such as computer 14 or server 16 (of Fig. 4), that the head condition is defective or inadequate by reporting "can't restore head". After performing Step "S10", the process proceeds to Step "S11".

In Step "S11", the processor terminates implementation of the smart cleaning algorithm.

In Step "S12", the processor quits, terminating implementation of the smart cleaning algorithm.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

CLAIMS

What is claimed is:

1. A tape drive cleaning cartridge (20), comprising:

a data tape segment (38);

a cleaning tape segment (40) associated with the data tape segment (38); and

a tape carrier (22) configured to carry the data tape segment (38) and the cleaning tape segment (40) for selective positioning along a magnetic transducer head (68) during a head performance verification operation and a head cleaning operation, respectively.

2. The tape drive cleaning cartridge of claim 1 wherein the tape carrier (20) comprises at least one tape reel (22).

3. The tape drive cleaning cartridge of claim 1 wherein the data tape segment (38) contains servo written data operative to test transducer head (68) performance on a tape drive (12).

4. The tape drive cleaning cartridge of claim 1 wherein the data tape segment (38) comprises position data.

5. The tape drive cleaning cartridge of claim 1 further comprising memory (64) configurable to retain information quantifying the extent of cleaning undertaken with the cleaning cartridge (20).

6. The tape drive cleaning cartridge of claim 1 further comprising communication circuitry (62, 66) and memory (64) operative to communicate with a tape drive (12) and configured to store retrievable information of cleaning cartridge usage.

7. A method for cleaning a transducer head (68) on a tape drive (12), comprising the steps of:

providing a cleaning cartridge (20) having a tape (24) including a data tape segment (38) and a cleaning tape segment (40);

receiving the cleaning cartridge (20) into a tape drive (12);

operating the tape drive (12) and the transducer head (68) in order to transfer data between the data tape segment (38) and the tape transducer head (68);

detecting when the tape transducer head (68) requires cleaning;

advancing the tape (24) along the cleaning tape segment (40) in response to the detected need for cleaning, the advancing resulting in the cleaning tape segment (40) effecting a cleaning operation on the tape transducer head (68); and

advancing the tape (24) to the data tape segment (38) to detect whether the transducer head (68) is clean.

8. The method as described in claim 7 comprising testing the transducer head (68) and characterizing the level of contamination determined therefrom.

9. The method in accordance with claim 7 comprising detecting advancement of the cleaning tape segment (40) along the transducer head (68) in order to quantify the level of cleaning.

10. The method in accordance with claim 7 further comprising monitoring usage of the cleaning tape segment (40) when cleaning the transducer head (68) and determining when the monitored cleaning exceeds a threshold value.

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19

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Databases searched:

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Other: ONLINE: WPI, EDOC, JAPIO.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2262505 A	(JACOBS)	1,2
Y	EP 0720163 A2	(SONY CORPORATION) (Column 8 lines 33-44 and Fig.7)	5,6
X, Y	EP 0617427 A2	(MINNESOTA MINING AND MANUFACTURING CO)	X:1-4, 7-9 Y: 5, 6
X	US 3827699	(MALLORY AND CO INC)	1,2

X Document indicating lack of novelty or inventive step
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A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.